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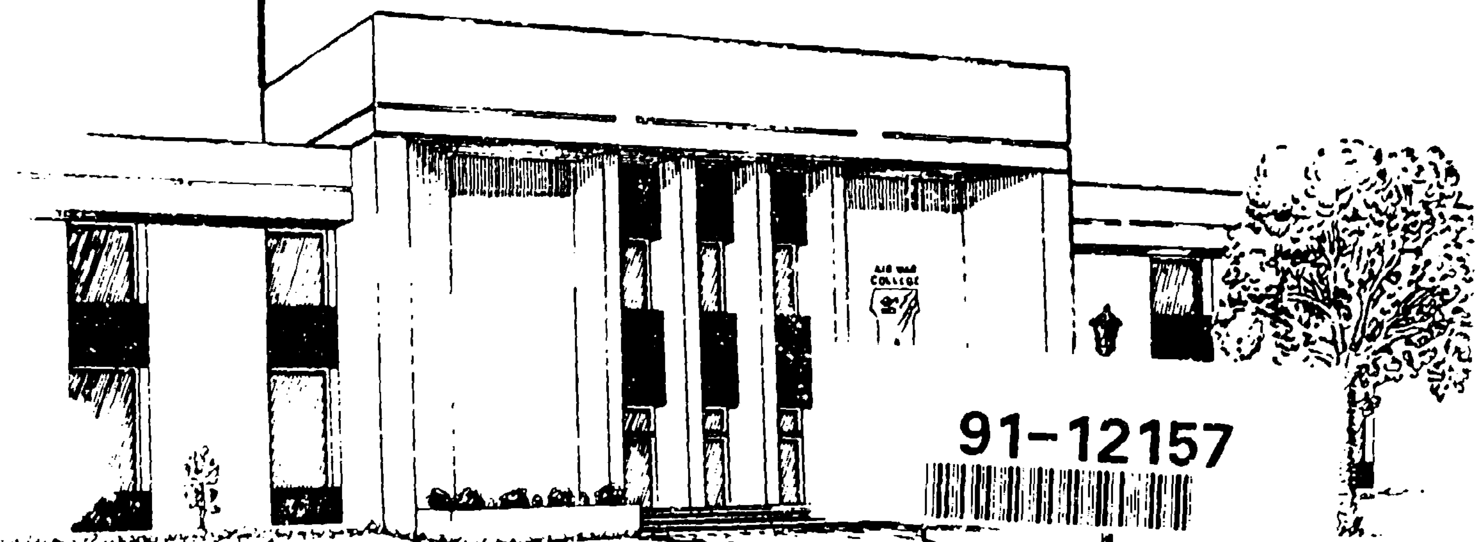
RESEARCH REPORT

NIGHT VISION AND NIGHT VISION GOGGLES

LIEUTENANT COLONEL THOMAS W. OLDHAM

1990



AIR UNIVERSITY
UNITED STATES AIR FORCE
MAXWELL AIR FORCE BASE, ALABAMA

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NIGHT VISION AND NIGHT VISION GOGGLES

by

Thomas W. Oldham
Lieutenant Colonel, USAF

A DEFENSE ANALYTICAL STUDY SUBMITTED TO THE FACULTY

IN

FULLFILLMENT OF THE CURRICULUM

REQUIREMENT

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EXECUTIVE SUMMARY

TITLE: Night Vision and Night Vision Goggles

AUTHOR: Thomas W. Oldham, Lieutenant Colonel, USAF

Night Vision Goggles (NVG) do not turn night into day. In fact, they have limited performance capability. This article addresses the rational for low light operations, how NVGs work, and various NVG limitations. Knowledge of the NVG performance envelope, inherent NVG limitations, effects of human vision deficiencies, and factors of self-imposed stress, constitute the formula for determining safe maneuver limits. The article concludes with recommendations to improve NVG use and affirms that NVG are safe for helicopter operations.

BIOGRAPHICAL SKETCH

Lieutenant Colonel Thomas W. Oldham is a command pilot with operational experience in Strategic Air Command and Military Airlift Command flying KC-135A and WC-135B aircraft, respectively. He also has five years experience on the Air Staff as an action officer in the Mideast/Africa Divison, Directorate of International Programs. In his assignment prior to attending Air War College, Lieutenant Colonel Oldham was Assistant Chief of Wing Training and later, Chief of Wing Tactics for the 41 Rescue and Weather Reconnaissance Wing-- now Air Rescue Service. As a tactician, he was responsible for initial and continuation tactical aircrew training programs for 600 aircrew members, at seventeen units, operating seven different types of aircraft. Those training programs included combat rescue and tactical operations which encompassed low-level flight, electronic warfare, infiltration/exfiltration and the use of night vision goggles. He holds a BS from Florida State University and a MA from Ball State University. Lieutenant Colonel Oldham is a graduate of the Air War College Class of 1990.

TABLE OF CONTENTS

DISCLAIMER ii

EXECUTIVE SUMMARY iii

BIOGRAPHICAL SKETCH iv

Chapter

I. INTRODUCTION 1

WHY HAVE NVG CAPABILITY 4

HOW NIGHT VISION DEVICES WORK 6

VISION AND FLIGHT 7

VISION DEFICIENCIES 12

SELF-IMPOSED STRESS 13

OPERATIONAL CAPABILITY 16

II. INTERNAL LIMITING FACTORS OF NVGS 21

EXTERNAL FACTORS 23

III. CONCLUSION 27

BIBLIOGRAPHY 33

FOOTNOTES 35

CHAPTER I

INTRODUCTION

Karl Von Clausewitz stated in his writings that "War is the realm of chance. No other human activity gives it greater scope. Chance makes everything more uncertain and interferes with the whole course of events."1 Clausewitz probably never thought that a tool of war in and of itself would be a double edge sword which may improve the chance of success while adding a variable degree of chance of failure. The tool I refer to is night vision goggles (NVG) for aviators. Although Clausewitz was not in favor of night combat, this paper addresses the use of NVGs for night-time missions. The safety aspect of night vision goggle use is examined in the context of combat rescue missions associated with low light, low-level tactics and associated maneuvers. Is night flight using NVGs safe? The question involves two issues. One has to do with the capability and performance of NVGs and the other deals with tactics and maneuvers. I will examine the issue of NVG performance and capability from the H-3 helicopter aircrew point of view and the AN/PVS-5 NVG system. Both the aircraft and NVG system are less than state-of-the-art. The USAF is acquiring H-60 helicopters and AN/AVS-6 NVGs as replacements. The excellent safety record should only improve as reliability and capability of the equipment improves.

Please note that neither Military Airlift Command (MAC) nor are helicopter crews the only users of NVGs. For example, Strategic Air Command has an NVG program for bomber crews, Tactical Air Command has an NVG program for fighter crews and the US Army has an NVG program for both infantry and aircrews.2 In fact all four United States Military Services and the Coast Guard employ NVGs, to some degree, for air, sea, or ground use or a combination of the three.3

Additionally, for the purposes of this paper, I am working with the premise that the helicopter tactics and maneuvers, which are currently employed, are necessary and satisfactory to defeat the various threats which can be encountered. NVGs only limit the aircraft speed and angle of bank at which the pilot can safely execute these maneuvers. NVGs permit operators to fly under conditions, which would be impossible by reliance solely upon the unaided eye, but only within certain perimeters during low-light conditions. Flight within those perimeters, and threat avoidance planned to remain within those limits are part of the mission objective. That is what aircrews are taught and what they practice at their MAC units. Because the tactics involved in defeating various threats are classified, no additional comments will be directed to that subject.

Training is a key factor in the creation of and maintenance of any skill and NVG training is no exception. Individuals selected for NVG training are day mission qualified in their assigned aircraft. This insures a high level of weapon system knowledge and experience, thus allowing the individual to concentrate on NVG training alone. NVG initial and mission qualification training is divided into academics and flying training. Academic instruction consists of approximately seven hours of classroom work plus "homework" which covers topics such as: basis NVG description and functions, night vision physiology, NVG operation, aircraft preparation and tactical applications. Flying instruction consists of ten sorties, about 20 hours of flight, including the qualification evaluation. Once qualified, aircrew members maintain NVG proficiency by accomplishing recurring training requirements. Currency training requirements typically involve: a minimum of one NVG sortie every 60 days, a minimum of 3 tactical mission sorties each six months, and a minimum of two air refueling sorties each six months. There are variations regarding these requirements, but the point is that NVG training is required on a regular basis.

There are human factors and external limits which come into play for night vision and NVGs. I will attempt to show that NVG use for night flight can be a safe and useful tool. A common perception among nonusers of night vision devices is that NVGs can turn night into day. That perception is wrong. NVGs do improve the ability of an individual to see in the dark; however, there are several limitations which must be considered for aircraft operations. Before addressing various NVG limitations, the rational for low light operations, examination of how NVGs work, and human performance factors will be addre first.

WHY HAVE NVG CAPABILITY

Tactical aircraft capability is necessary to counter Soviet military doctrine which calls for night operations of mobile, armored units. Additionally, a number of Soviet weapons have acquired night capability through the use of fire control radar, laser range finders or night vision sights. The ZSU 23-4, S-6 anti-aircraft guns and SA-7, 9, 10, 12, 13, and 16 surface-to-air missile are a few of the weapons which can incorporate some type of night capability to engage enemy aircraft.4 To match doctrine with capability, about one third of Soviet training time is devoted to night exercises. The highly mobile armored units are in the first and second echelons of attack and not only provide defense but constitute part of the offensive threat to US/Allied forces. Surprise is a key element in Soviet Doctrine.5 It is an essential element to attack using speed and strength to avoid a conflict of attrition. These mobile units as well as fixed targets often include anti-aircraft weapons and surface-to-air missiles as protection and defense against counter air operations.6 Avoidance of these weapons in areas where combat operations are being conducted is paramount for aircrew and aircraft survival. Avoidance may be as simple as not flying directly overhead of these threats or a more complicated manner of low-level night flight to avoid detection for special operations or combat rescue missions. Since the Soviets export many of their weapons abroad, similar usage of the weapons and concert with the military doctrine can be expected in client countries which have obtained Soviet arms.

Another reason for night operations, besides countering Soviet doctrine and weapons capability, is that the ability to use the cloak of night gives the user the advantage of surprise. It is also a psychological advantage for one side in that an enemy knows he cannot safely rest at any time and that darkness will not stop our operations or cover theirs. There are several unclassified examples which demonstrate NVG capability. To avoid threats and have the advantage of surprise in the initial stages of Operation Just Cause in Panama, US Army troops were deployed to various unlighted landing zones on unlighted helicopters by pilots flying on NVGs.7 Another example of NVG work was shown on ABC News. The Iranian night-time mine laying operation in the Persian Gulf was detected by US Army helicopter pilots using NVGs during Operation Earnest Will (US Flagged Kuwaiti Oil Tankers). In both cases NVG capability was part of the key to success. The element of surprise was achieved in Panama and mine laying operations in the Persian Gulf were stopped.

HOW NIGHT VISION DEVICES WORK

Let's examine how night operations can be conducted through the use of high technology in the form of night vision goggles. Litton Industries, a leading US manufacturer of NVGs, describes the product as "two identical monocular optical devices that amplify existing light by means of an image intensifier and focus it onto a photocathod where it becomes and electronic image which is visible to the eye."8 Magnification is typically one power, the same as you would see with the naked eye. That seems straight forward enough: a pair of binoculars that projects an electronic image for the user to view. The human eye is complex sensor; we must understand its fundamental makeup in order to understand the NVG-vision relationship.

VISION AND FLIGHT

Of the five senses, only three, vision, touch, and hearing are used in the normal events of flight. Vision is the most important sensory function used in flight. The typical flight regimen is multi-dimensional, involves speed variations and directional changes. The visual sense provides the overwhelming majority of input of data for aviator control actions and is least likely to cause pilot or aircrew disorientation. In the event of disorientation, vision is the only sense which can provide the proper input to the brain which will most likely overcome the disorientation factor. For example, during a level turn, with no change in speed, the sense of touch will adjust so the aircrew member no longer senses the turn. Visual clues outside the aircraft indicate the aircraft is not wings level to the horizon and viewing of the instrument readings indicate that the aircraft direction or heading is continuing to change. Vision also includes depth perception and peripheral vision. Both are necessary for safe flight to identify obstacles, terrain features as well as takeoffs and landings. During daylight hours, individuals who possess 20/20 or corrected to 20/20 vision, have no restriction on peripheral and depth perception visual abilities. As darkness increases, the visual clues seemingly disappear, and vision becomes limited. A person that may have 20/20 vision in daylight may have reduced, limited or no night vision due to physical limits or self-imposed stresses. Both physical limits and self-imposed stresses will be discussed later.

In basic terms, vision is the reception of focused lightwaves upon the retina. The retina is made up of sensors known as rods and cones. Cones function only in daylight or artificial equivalent. Cones are the portion of the eye structure which is responsible for the colors which are discernible and sharp focus. This type of vision is known as photopic and the eye views objects along the central vision axis of the eye and scans a field-of-view using central vision.[9] Rods are located primarily in the peripheral part of the retina and do not perceive color but do perceive shape, but with less acuity than cones. In low light conditions, the cones cannot be stimulated but the rods, which are more numerous, somehow bond together for transmission of the lightwaves to the optic nerve. This type of vision is known as scotopic. Visual acuity decreases to 20/200 or less. Viewing of objects must be accomplished by off-center viewing.10 Where the optic nerve and retina meet, a blind spot occurs because the are no rods or cones. An aviator, properly trained in NVG use, can safely overcome decreased visual clues due to darkness and the blind spot in night flying because of NVG generated electronic images. Without NVGs, night flying is hazardous without some type of illumination aid to activate the cone function in the eye. In a combat mission scenario, a lighted landing zone is unlikely to be available nor would surprise be a key factor in determining the success of the mission.

Depth perception, peripheral vision, and visual illusions are other factors which also must be addressed. Depth perception is often mentioned as a problem with NVG users.11 This is due to the lack of contrast between objects which provide distance clues. Aircrew instructors teach various methods to judge depth or distances. Two methods involve examination of object size changes and loss of object texture. For example, if a object image is increasing in size then motion is towards the object; if it decreases in size then motion is away from the object. The less detail that is discernible, the greater the distance to the object.

Former 23 AF Medical Advisor, Dr. Hammer, has stated in point papers that "NVG best case visual acuity is 20/50."12

With visual acuity reduced, the pilot may not see movement or changes in relative position.13 Compounding the loss of visual acuity is the loss of peripheral vision. Dr. Hammer also found that "NVGs reduce the field of vision to only 40 degrees."14 Normally, field of vision is approximately 200 degrees. Depth perception is significantly reduced with NVGs (as opposed to unaided vision) when the viewing difference increases beyond 300 feet.15 The reduced visual acuity (20/50) makes objects appear to be fuzzy. That by itself degrades depth perception. Restriction of the field of view to 40 degrees impairs the ability to detect movement and increases head movement as the crew members attempts to increase the area viewed. Head movement combined with undetected movement and fuzzy images contributes to spatial disorientation or visual illusions. To illustrate my point, take a letter size piece of paper and roll lengthwise it into a tube about one and a half inches in diameter. Place the tube up to one eye while covering or closing the other eye. Look straight ahead. Now balance yourself on one foot. To make it more interesting, try the same maneuver in darkened room. The experiment should have demonstrated how a reduced field of vision limits visual clues for orientation in order to maintain balance. With practice, it would be possible to recognize movement and maintain balance with a restricted view. Either disorientation or illusion can be a contributing cause to an accident if the pilot does not recognize that situation and then immediately rely on aircraft instruments for reference. To reinforce recognition of and recovery from spatial disorientation and visual illusions, these topics are discussed in safety meetings, instrument refresher courses, NVG instruction and applicable aircraft simulator classes.

Visual illusions are not isolated to the flying environment alone. There are several illusions such as autokinesis, the apparently movement of a static light when focused upon in the dark, and relative motion, which is the sensation of moving when static. For example, you are stopped in traffic and the car next to you moves backward. The sensation is that of forward motion. Similar illusions can occur in everyday life. In the flying environment, these two illusions plus the following illusions: confusion of ground lights with stars, false horizons, height-size-distance illusions, flicker vertigo, and fixation all represent the danger of spatial disorientation which may result in loss of control of the aircraft. Dr. Hammer has concluded that the significance of visual illusion and NVGs is that with reduced field of view and reduced visual references, "There is an increased probability of spatial disorientation."16 Educating aircrew members to recognize visual illusions and develop techniques to compensate for reduced visual clues for depth perception are the only current means of coping with these hazards. Complicating this situation are two visual deficiencies, presbyopia and night myopia, which can occur.

VISION DEFICIENCIES

Presbyopia is a vision deficiency which is common in people over the age of 40. It is the loss of the eye's ability to accommodate diverging light rays from near objects. A hardening of the lens occurs which adversely affect the eye's ability to focus red light on the retina.17 The significance of this is that the red colored light does not interfere with the highly light sensitive rods of the eyeball for producing images in darkness. Historically, red light has been found to be the best color to adapt the eye for night vision and consequently, aircraft instruments are normally illuminated by red light at night. The inability to focus the image shown in red light upon the retina is corrected by wearing bifocal glasses which can focus the light for the user. These bifocal eye glasses are the same type of eye glasses found at the local optical shop. The second deficiency is night myopia. It is defined as the spectrum of available light changes so that blue (wavelengths of) light prevail. An individual who is slightly nearsighted will have more difficulty at night resulting in blurred vision if not corrected by prescription lenses.18 That is to say, in the spectrum of visible light, blue is the dominate color and some nearsighted individuals cannot sharply focus on object without a special night vision optical lens in prescription eyeglasses.

The significance of both these deficiencies is that they negatively impact upon normal night vision capability. In the case of presbyopia, a pilot on a rest period or otherwise not using NVGs could not read the aircraft instruments because they are typically illuminated in red light. Night myopia is a concern because NVG electronic images are green to blue-green in appearance and require the special eyeglasses. Also there is a change is underway to convert aircraft instrument illumination to blue lights. One of Dr. Hammer's findings was that the normal, unaided eye is more receptive to blue light at lower levels of intensity. Both vision deficiencies can be corrected by through medical means, however there are additional factors, referred to as self-imposed stresses, that only the individual can control.

SELF-IMPOSED STRESS

The most common self-imposed stresses affecting night vision are the affects of oxygen, tobacco, alcohol, fatigue, nutrition, and physical conditioning. Night vision is dependent upon optimum function and sensitivity of the rods in the retina. Lack of oxygen significantly reduces rod sensitivity, increases dark adaptation time and a decreases night vision.19 Dr. Hammer further states the importance of oxygen in night vision.

> The retina is an outcropping of the central nervous system and has a high oxygen requirement. Flight above 5000 feet MSL (mean sea level) without supplementary oxygen, reduces visual acuity by 25%. When ever oxygen saturation in the blood drops to 87% or less, hypoxia (lack of oxygen) occurs.20

Tobacco, whether smoke or smokeless form, constitutes a hazard. According to Dr. Hammer, "Carbon dioxide is present in tobacco smoke to the extent that it saturates hemoglobin in smokers to levels as height as 10-15%."21 This results in reduced capacity of the blood to carry oxygen and contributes to hypoxia (Oxygen deprivation to the brain). Dr. Hammer found that "This negatively impacts visual acuity, brightness, visual discrimination, and dark adaptation."22 Additionally, tobacco contains a drug called nicotine. Dr. Hammer identified its affect. "Nicotine has actions on the central nervous system which are dose dependant and both stimulant and depressant. The key is that nicotine is a retinal vasoconstrictor (decreases blood flow) and diminishes night vision."23 Alcohol has the effect of sedation and causes a lack of coordination and impairment of judgment.24 Although flight rules prohibit consumption of alcoholic beverages for at least eight hours prior to flight, the effects of residual alcohol or a hangover will also impair visual efficiency. If a person is fatigued when performing night flight, they will not be mentally alert and proper techniques of night vision will not be applied. Situational responses will be slow and there is a tendency to concentrate attention in one area without consideration for the total requirement.25 Also directly contributing to fatigue is the act of flying on NVGs. Both Dr. Hammer and the USAF NVG instructional guide state "The workload is 2 to 4 times greater under the NVG flying than in daytime flying. Movements at night were observed to be greater in magnitude and movement than in daytime flight. The movements were twice as large and occurred twice as often."26 Lack of proper nutrition can negatively impact night vision. The failure to eat foods that provide sufficient vitamin A could cause visual impairment. Excess quantities of vitamin A will not improve night vision and may be harmful. Missed meals can also exert an unpleasant feeling, cause distractions, break habit patterns, and shorten the attention span.27 Physical conditioning improves stamina and reduces the effects of fatigue and other physiological stresses of night flight. Any one or combination of these self-imposed stresses can impair an aircrew member from performing at the necessary level to safely accomplish the mission. The severity of the self-imposed stress level and the flight circumstances combine in determining the outcome. For example, use of tobacco products may inhibit night-time visual acuity to the point that an obstacle is not seen and impact with it occurs. The point is that night flying is complex in and of itself without complicating it more with stresses that can be avoided.

OPERATIONAL CAPABILITY

Now that we have briefly reviewed the visual performance perimeters and physiological factors, we will examine the NVG technological limitations and operational factors. Restating how NVGs work, these electro-optical devices amplify light and focus images on an eyepiece for the user to see. Several technical factors effect what the user can see. Specifically, these are ambient light level, visibility, speed and object contrast. Each one is an element in determining NVG capability within a given set of conditions.

Ambient light is basically starlight and moon illumination. Cloudcover and phases of the moon determine available light. Visibility is the range at which a manmade or natural feature can be identified. Meteorological conditions such as fog, haze, smoke, rain and snow restrict ranges at which objects can be identified. Speed effects viewing time of objects and reaction time to objects. Object contrast is the difference between the object and the background which surrounds it. Altitude and ambient light affect the view as does the terrain. Because visual acuity decreases with height, reference points and distinguishing terrain features become hard to see. Deserts reflect light whereas mountains block light and become silhouette. Part of tactical mission planning is to determine NVG distance range based upon visibility and ambient light in order to calculate a safe speed for operations.

To determine the range for object identification, enter the range identification chart along the line representing the percentage of moon illumination. Move up until intersecting the visibility and contrast lines for the flight conditions. The range for object identification can be determined by comparing the intersecting plot with the range scale on the left side of the chart. After the range has been determined, the groundspeed limitation chart is used to determine a safe speed for NVG flight. Enter the graph on the left side at a point representing range distance that was calculated on the range chart. Move across the graph to the right until intersecting the desired response time. From the intersection, move down the chart to the groundspeed scale. That is the safe speed for flying with NVGs. Consideration should be given to pilot

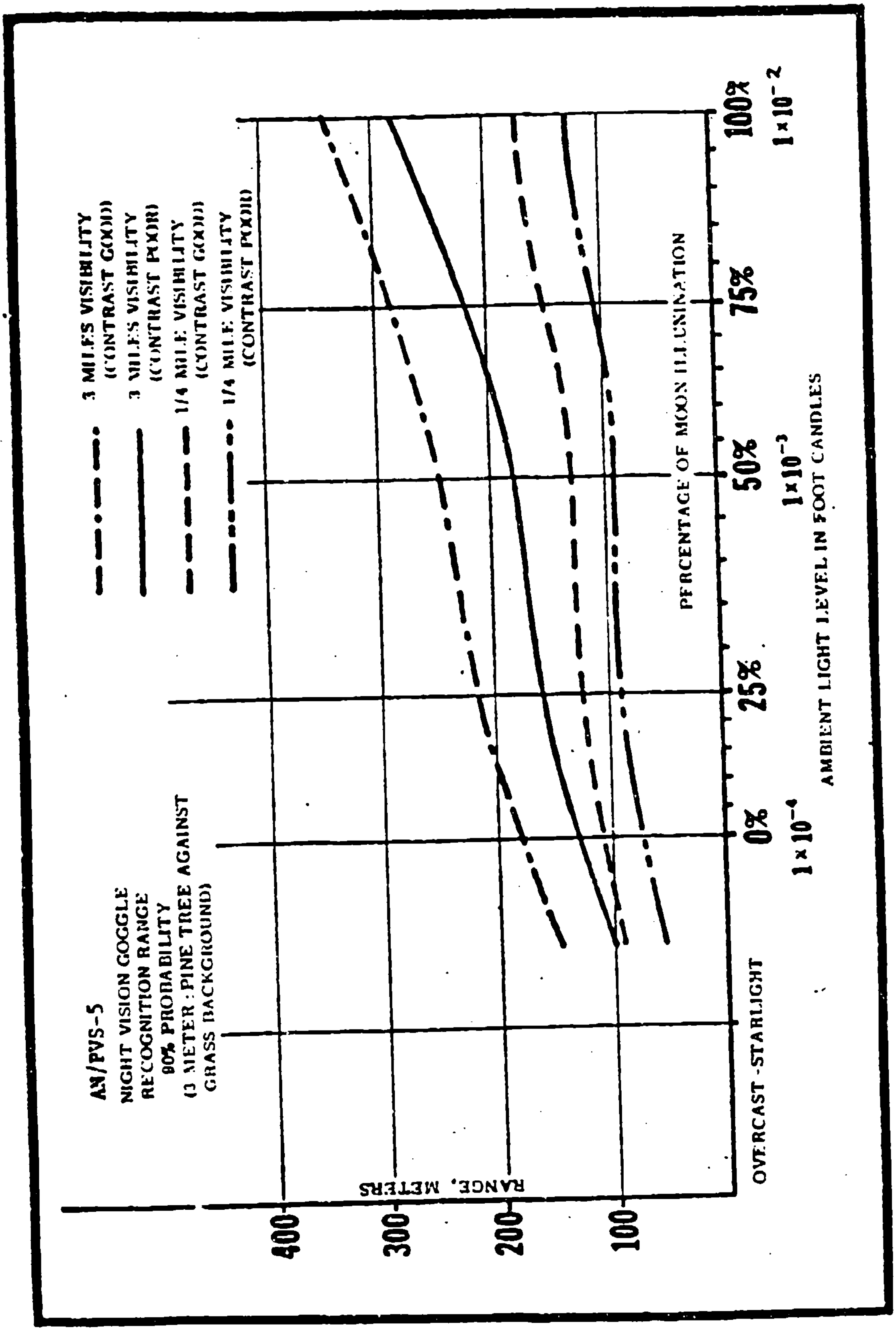

Chart from 1550 CCTW

AN/PVS-5 Range Identification

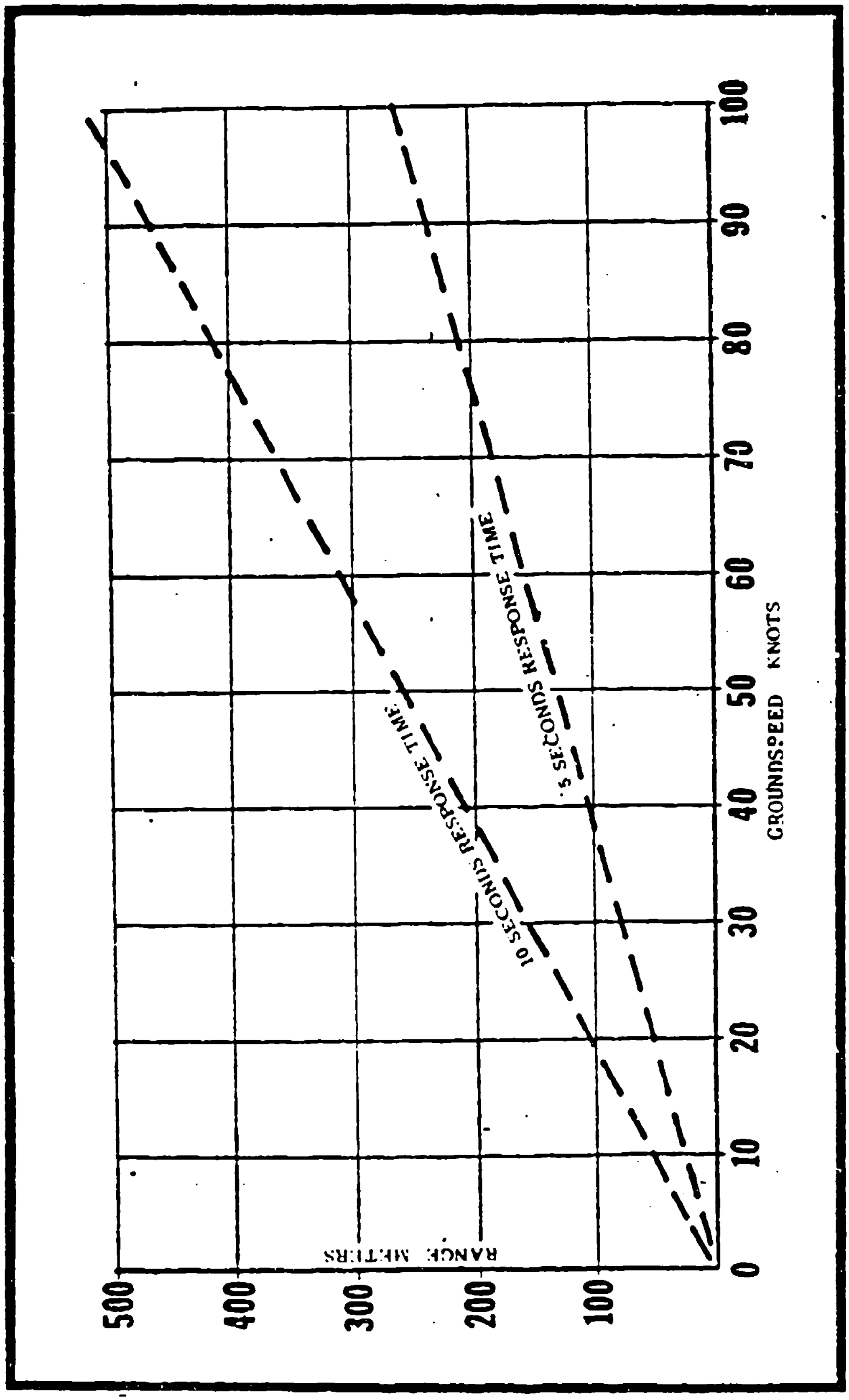

Chart from 1550 CCTW

AN/PVS-5 Groundspeed Limitation

proficiency and aircraft performance in selecting response time. For example, a proficient pilot flying at high field elevations may elect a ten second response time due to decreased aircraft performance at high pressure altitudes.

Some limiting operational factors have been previously identified in conjunction with discussion of depth perception and peripheral vision. For quick review, NVG best case visual acuity is 20/50 and the normal field of view is reduced from 200 degrees to only 40 degrees. Also, the reduced visual acuity and field of view increase the probability of visual illusions and spatial disorientation which may cause loss of aircraft control. I will divide the other limiting factors into external and internal environment factors. Internal factors are those items inherent in NVG design and external factors are all other items affecting NVG performance.

CHAPTER II

INTERNAL LIMITING FACTORS OF NVGS

One of the most serious internal limits is NVG focus range. NVG focus procedures are difficult in changing the focus from inside viewing of cockpit instruments and then return to visual scan outside the cockpit. Pilots that I have spoken with, either look around/under the NVG or refocus the lens in order to clearly see the display. This can be a serious and time consuming distraction if attention is required inside the cockpit while flying low level. For example, a warning light on the instrument panel illuminates and it is necessary to cross check the warning light with another instrument to confirm or reject the warning indicator. It is easier to look under the NVG than attempt to refocus the lens.

Until recently, NVG users and maintenance personnel had no means to determine proper lens focus and the effectiveness of NVG amplifier tubes. This resulted in NVGs which could seriously degrade visual acuity of the user and induce eye fatigue. 23 AF/DOT (training) provided guidelines for NVG adjustment and focusing. It called for a calibration lane with specific distances and specific lighting requirements which is to be used in conjunction with a visual acuity chart. This preflight action will correct any out of focus condition and identify deficient amplifier tubes. Lighting also has an effect inside and outside of the cockpit. Red light is best color for adaptation and maintenance of night vision. Dr. Hammer has stated that "Red light is not the most compatible with NVGs because that wavelength is the most discernible one to NVGs."28 As a consequence, cockpit lights must be turned very low or off to prevent blinding the crew member on NVGs. In contrast, Dr. Hammer found that "The most detectable color for unaided night vision is blue-green. The blue-green light wavelength spectrum appears to create the least glare and is the most compatible for NVG operations."29 Accordingly, within 23 AF, all cockpit lighting is being changed in their special operations aircraft from red to blue-green in order to accommodate the NVG user. Also, within MAC, blue-green lighting is required in H-3 helicopters which are used for NVG missions.30 This color arrangement can be a problem around ground personnel because it will not preserve their visual dark adaptation. A variation on lighting problems is that not all crew members will necessarily be wearing the same type of NVG and each model has different light sensitivities. Another problem is map reading. Maps are very difficult to read because of the detail and again having to refocus the NVG lens.

Careful map preparation is essential, considering the difficulty in recognizing terrain features and looking inside to focus on a map.

EXTERNAL FACTORS

One of the most serious hazards to NVG flight are wires or power lines across the route of flight that cannot be seen.31 The size of the cable make it almost invisible even with the NVG. Several companies are working on an low power infrared radar which connects to the NVG system to warn pilots of obstacles in the flight path. NVG training is normally conducted over thoroughly surveyed areas with known flight hazards identified on training charts. The problem of wires occurs when they are strung with no notification as is often found in South Korea and the Philippines. Naturally this can be a problem over hostile territory where surveys cannot be done and charts may not be accurate. Crew members are taught to scan for clues which would identify the path of wires by locating poles or towers which carry the lines.

Weight and balance of NVGs is next most serious problem. The NVG system, which is helmet mounted, weighs about two pounds. This seemingly light weight becomes heavy to the user in as little as two hours because the NVG weight is not evenly balanced.32 The helmet and NVG system become uncomfortable in two hours yet my experience is that missions often exceed three or more hours in duration. Counterbalancing the weight adjusts the balance but the increased weight makes the helmet more of a burden to wear which induces fatigue and the associated physiological factors.

Additionally, aircraft structures, either windscreen frame, canopy or overhead panels interfere with NVG usage. The structures either partially block the view or interfere with raising the NVG to a stored position when not in use.33 The Superintendent of Life Support Equipment for Air Rescue Service, Master Sergeant Leamons, recently identified a problem of donning a smoke mask if NVGs are in use. The NVGs must be completely removed for the wearing of a smoke mask when the aircrew experiences smoke and fumes in the aircraft. Although smoke will not effect the NVG, the crew members' eyes and respiratory system must be protected and the goggles are simply in the way. Dr. Hammer's point papers also identify the NVG helmet mounting systems are not crashworthy. The NVG brackets are screwed or glued to the helmet and the separating NVGs may cause injury to the user because the mount cannot withstand the forces involved in a crash.

USAF NVG instruction guide notes that weather causes other problems with NVGs. In cold temperatures, the eyepiece lens will fog up. Heat causes the user to perspire and the beads of sweat that drip onto the eyepiece lens will distort the view until the lens is dried. Power to operate the system requires batteries as the source of power. Although batteries are testable to determine if they are charged, the length of battery life for NVG operation cannot be determined.34 For that reason, crew members carry spare batteries that are readily accessible inflight. Batteries also have a history of failure due to rupture, venting or explosion. This long list of operational limiting factors are all known factors. As known factors, aircrew members continue to account for them in the planning of training flights or actual missions.

Another external element, speed, is perhaps the one of the most important. The NVG illumination ability is a combination of ambient light and prevailing visibility. Examination of the range and groundspeed charts clearly show that the greater the ambient light level in conjunction with higher prevailing visibility, the faster the speed the NVG user can safely travel. For flights conducted within the illumination, visibility and contrast conditions listed on the charts, the user will have a 90 percent chance of recognizing intended references.35 A 100 percent chance is not possible. This is due to reduced acuity and reduced field of view with the NVG plus the inherent blind spot in the eye. With NVGs, like headlights on an automobile, it is possible to travel faster than it is possible to recognize an object or situation, a rock or dip in the road for example, and react in time to safely maneuver. A big variable in this formula is visibility. It can change moment to moment as the flight proceeds and the associated airspeed changes cannot be matched that precisely to variable light and visibility conditions. If reduced visibility conditions are entered, crews are taught to reverse course or transition to instruments and climb in altitude to avoid high terrain.

CHAPTER III

CONCLUSION

The frailty of the human vision system cannot be ignored. Homosapiens are day animals and the rod and cone structure of eye/brain sensing system is designed for visual acuity with high levels of natural or artificial light. Humans with good day vision may not have good night vision due to presbyopia or myopia. Both affect the ability to focus at night. There are various associated physiological stresses which also impact the efficiency and acuity of the vision system. Low oxygen levels, chemicals from alcohol and tobacco, fatigue and poor nutrition all negatively affect visual acuity. Despite the many frailties in human vision, humans can attain very good visual acuity, (20/50)in darkness, with technological assistance. To do so, means that those limitations must be addressed to accommodate or overcome those shortfalls. However, technology alone cannot totally overcome inherent problems in human night vision such as night myopia and illusions. The current NVGs improve normal human night vision from 20/200 to 20/50 in very low light conditions. NVGs restrict the field of view and can produce other possible effects on depth perception and spatial orientation.

The key to eliminating the potential problems in using NVGs is fourfold. First, an initial medical screening of personnel for night vision acuity should be done prior to any assignment which would involve NVG use. Currently, personnel are screened for night vision problems only after seeking medical assistance. Periodic examinations should also be conducted to determine if there are any changes in night vision acuity as long as they are involved in NVG operations. Exams should include night vision checks for any onset of myopia or presbyopia or other loss of unaided night vision. At present, there is no USAF wide visual acuity testing program. Very few doctors are involved at bases where NVG missions are ongoing.36 Secondly, based upon my review of NVG training manuals, I believe aircrew education of physiological limits regarding physical effects and self-imposed stresses of NVG flight has been excellent. Visual illusions and spatial disorientation received special attention because reduced visual acuity and field of vision are conducive for occurrences of both problems. Perhaps a semiannual vice an annual review period of training, including recovery techniques may be of some benefit. Thirdly, NVG training, both initial and continuation, should be maintained at current levels. The practice of selecting only day mission qualified crew members for NVG training should be maintained because of the flight proficiency required for initial qualification. The current NVG initial and continuation training program, as described in the introduction, appears to be of the necessary depth and of significant duration to maintain NVG skills. Like other flying skills, or even other educational pursuits, a firm foundation with periodic maintenance of that skill, will maintain a high level of proficiency. Fourth, maintenance procedures must be more readily shared. The USAF has no standardized preventive and functional maintenance procedures.37 Each life support unit does maintenance according to the way they understand the NVG owners guide. Another example is the NVG calibration lane for testing NVGs. Within the USAF, this is a 23 AF initiative and is not a standard testing procedure.

Based upon current USAF operations, properly educated and trained personnel have operated safely at night, within the limits of established NVG performance envelopes and will most likely continue to do so. Aircrew safety is not unnecessarily being compromised by using NVGs. I believe the helicopter safety record does not depict NVGs as a hazard. No crash to date has been directly attributed to NVGs as the sole cause.38/39 Total helicopter flying hours include NVG flying hours but do not specifically categorize the percentage or exact number of hours of NVG use. This situation makes it difficult to prove a positive. We know that if an aircraft crashes that all aspects of the mishap will be investigated to determine the cause. When a flight is successful, no investigation is conducted to determine cause. For example, in FY 1988 and FY 1989 combined, there was a loss of three H-3 helicopters. 40/41 The safety report did not identify NVGs as the primary or contributing cause in the three mishaps. USAF records show about 23,000 flying hours for 65 H-3 aircraft during that timeframe.42 Although they are being phased out, these aircraft are used for combat rescue and special operations. My past experience is that approximately 20 percent of H-3 combat rescue flying time is used for NVG training. A conservative number (conservative because special operations units typically use 80 percent of their flying hours for NVG training) of H-3 NVG flying hours is 4,600 for the same time period. My deductive conclusion is that NVGs are safe and not the hazard the news media would have you believe.

The media and Congressional attention to NVGs was brought about by a rash of US Army helicopter crashes. One magazine report indicates the Army had 106 helicopter crashes from 1986 through 1989. In twelve of the crashes, NVGs were being used. The safety report indicated NVGs were an accident factor in six of the crashes.43 An Army response to Congressional inquiry was slightly different. From 1978 through 1988, there were a total of 397 losses. 107 of the crashes occurred at night and only 39 involved the use of NVGs. NVGs were not identified as the primary cause in any of the crashes and no mention was made of contributing cause.44

The USAF strives for accident free flying. The losses have been small in number but tragic nonetheless. The helicopter safety record is exemplary despite the losses and the complexity of the combat rescue mission.

NVG support from an operational standpoint comes from "Operation Just Cause". Although it does not address combat rescue, the operation involved helicopter aircrews using NVGs to ferry troops to various locations for combat operations. LTG Stiner, 28th Airborne Commander, stated that "I will always ask to go at night. It's added security for us and gives us the added advantage that we need in a forced entry operation."45 There were no reports of helicopter accidents or losses during Operation Just Cause.46

I consider NVGs as new tools which are only going to improve technologically in performance and capability. The development and employment of the AN/AVS-6 NVG, a step beyond the AN/PVS-5 NVG, is such an example. There are two quotes from General Douhet which formulate enduring concepts with which to view new tools. "The form of any war-and it is the form which is of primary interest to men of war-depends upon the technical means of war available."47 The war in the air is the true war of movement, in which swift intuition, swifter decision and still swifter execution are needed. It is the kind of warfare in which the outcome will be largely dependent upon the genius of the commanders."48 NVGs, when used within their specified operational limits, provide a commander a new technology with which a war can be quickly prosecuted and only his imagination will be the limitation in how night fighters are used.

There is an anonymous quotation which is used by some special operations and combat rescue personnel regarding tactics. "If you can be seen, then you can be hit. If you can be hit, then you can be killed." NVGs do not make aircrews bulletproof but they permit safe flight in conditions which make them very hard to be seen.

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